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(54) **DISPLAYS WITH MINIMIZED BORDERS**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,066,855	A	1/1978	Zenk	
4,085,302	A	4/1978	Zenk et al.	
5,235,451	A	8/1993	Bryan	
5,436,745	A *	7/1995	Voisin et al.	349/58
5,483,261	A	1/1996	Yasutake	
5,488,204	A	1/1996	Mead et al.	
5,825,352	A	10/1998	Bisset et al.	
5,835,079	A	11/1998	Shieh	
5,880,411	A	3/1999	Gillespie et al.	
6,188,391	B1	2/2001	Seely et al.	
6,310,610	B1	10/2001	Beaton et al.	
6,323,846	B1	11/2001	Westerman et al.	
6,504,530	B1 *	1/2003	Wilson et al.	345/173
6,690,387	B2	2/2004	Zimmerman et al.	
6,803,245	B2	10/2004	Auch et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

EP	2187443	5/2010
JP	9321083	12/1997

(Continued)

OTHER PUBLICATIONS

Chen et al., U.S. Appl. No. 13/186,238, filed Jul. 19, 2011.

(Continued)

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(57) **ABSTRACT**

An electronic device may be provided with a display having a flexible substrate with bent edges. The flexible substrate may have a planar active region that includes an array of light-emitting elements such as organic light-emitting diodes with associated control lines. The flexible substrate may also have inactive regions that lie outside of the active region. The bent edges may be formed from portions of the flexible substrate in the inactive regions. Traces for distributing control signals to the control lines in the active region may be formed in the inactive regions. Corner openings may be formed at the corners of the flexible substrate to accommodate bending of the flexible substrate in the inactive regions. A jumper or a portion of the flexible substrate that lies outside of a corner opening may be used to convey signals between traces on adjoining inactive regions.

17 Claims, 12 Drawing Sheets